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SELECTED ARTICLES ON PRESTRESSED CONCRETE DEVELOPMENT IN COMMUNIST CHINA

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SELECTED ARTICLES ON PRESTRESSED CONCRETE DEVELOPMENT IN COMMUNIST CHINA

TO PROMOTE, POPULARIZE AND IMPROVE THE APPLICATION OF PRESTRESSED CONCRETE IN 1960

/Following is the translation of an excerpt from the editorial of the above title appearing in Gongchung Jianshe (Engineering Construction) pp. 1-3./

In China, the use of precast reinforced concrete structures for construction has been developing steadily. In recent years, their use in building plants one-story tall or taller, civilian houses, and other constructions has been gradually extended. Generally speaking, however, the crack resistance of regular reinforced concrete members is not very good, and, hence the use of such reinforced materials for the above constructions becomes impractical. The addition, since the reinforced concrete materials are relatively heavier, their application in precast structures is restricted. However, some of the defects of reinforced concrete structures can be remedied by using prestressed concrete. The properties of prestressed materials -- high crack resistance, high degree of solidity and ligher weight -- can be utilized fully. The use of prestressed concrete not only saves large amounts of steel and concrete but also reduces the construction cost. Also, prestressed concrete is suitable for precast structures. For the above reasons, the extensive application of prestressed concrete structures is technically and economically significant.

Since the end of 1956 we have striven for and achieved great success in promoting the application of prestressed concrete. At the present time, under the leadership of the Communist Party, all construction units of various provinces, cities, autonomous regions, as well as the industry itself, have a true understanding of prestressed concrete. Depending on the requirements, we have trained staffs or workers to handle the production and application techniques of prestressed

concrete. Several hundred thousand cubic meters have been used for construction of various types of structures. Within this period many areas and industries established combined experimental units for research, design, and construction. During the period of rapid development of socialistic construction, the research, design, and construction of prestressed concrete structures also developed at a rapid pace. The types of prestressed concrete structures already used on a large scale include 12 to 18 meter roof beams, 18 to 36 meter arch and stair-shaped trusses, single unit or composite cantilever beams weighing less than 75 tons and spanning 6 meters, supporting trusses spanning 12 meters, continuous flat slabs, foundation beams and foundations. One of the new tall structures already in use is an arch roof truss spanning 61 meters, of concrete prestressed with steel wire installed with steel bands, in a mono-construction of the dome shell technique. Other structures include the 18 meter prestressed composite truss made of high-grade concrete, 35 x 35 meter hyperbolic shells, 5,000 cubic meter oil tanks (36 meters in diameter) and storage tanks for other purposes, prestressed concrete pressure pipes and piles used by various cities. During construction, besides the ordinary tensioning methods, electrical heat stressing of large-sized steel cables was also used. In experiments we made a 30 meter composite truss composed of straight, prestressed concrete posts, 14 meter composite columns, and we have successfully handled the electrical heat post-stressing, technique. Moreover, some units have been successfully made from high-strength and light-weight stress members, pozzolana concrete, concrete with entrained air, and silicon dioxide structural members. All these successes have aided us greatly in further promoting the use of prestressed concrete and in further consolidating and improving our techniques. We hope that the application of prestressed concrete for construction will soon be in full flower.

In the past few years, the successful use of prestressed concrete has proved again and agin that its promotion wholly conforms to the social construction policy of the Party, namely, "more, better and cheaper." According to the Institute of Construction of the Construction Engineering Department, a comparison between the economies of prestressed and nonprestressed concrete yields the following results. The use of prestressed concrete for trusses may require 19-71 percent less steel and 5-50 percent lower construction cost, for roof slabs, 29-58 percent less steel and 2-4 percent lower construction cost, for cantilever beams, 11-68 percent less steel and 39 percent lower construction cost, for foundation beams, 29 percent less steel and 3 percent lower construction cost. According to recent data, the use of one

6 X 12 meter prestressed cylindrical column thin shell in place of eight 1.5 X 6 meter roof slabs may require 31.6 percent less steel; the use of prestressed concrete hollow slabs instead of the regular reinforced concrete hollow slabs may require 89 percent less steel and 43.2 percent less cement; the use of 18 meter prestressed concrete electric posts, as against the use of regular reinforced concrete electric posts, may require 52.5 percent less steel and 19.2 percent less cement; and the use of prestressed concrete water conduits instead of metal conduits may call for 90 percent less steel. We are confident that further promotion of the application of prestressed concrete and its improvement will be of even greater technical and economical significance.

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Recently, construction workers and staffs have exerted greater efforts to revolutionize techniques and production processes and provide better equipment and materials. Because of this, we have full confidence that we will consolidate our foundations in the first year of the sixth decade of this century. The promotion of prestressed concrete will be fruitful. For example, the Construction Bureau of Shanghai and the Construction Department of Shansi Province have issued instructions for promoting the use of prestressed concrete and have further determined various goals for its promotion in 1960. The City Construction Bureau of Peiping has taken positive actions to the effect that 15 percent of all precast structural members are made of prestressed concrete. It suggested that prestressed concrete be used for trusses, cantilever beams, floor slabs and roof slabs. It also emphasizes the use of cold-drawn wire stress members, reinforced roof slabs, floor slabs, foundation and foundation-beam structural members. In Chekiang Province, Shansi Province and Shanghai, it is proper and necessary to use prestressed concrete structures on a large scale. Since the facilities and technical conditions in the subunits of the Chekiang Construction Bureau are not as good as in other construction units, the workers have had to adapt themselves to these simpler facilities and use cold-drawn wires. During the past year 3,800 cubic meters of prestressed concrete slabs, structures and foundations with tendons were used amounting to 76 percent of the total volume of prestressed concrete structures erected in the region. This year Chekiang Province plans to promote the use of 30,000 cubic meters of prestressed concrete, of which 20,000 cubic meters will be strengthened with tendons of various types. According

to the general records of the Third Engineering Bureau, Construction Engineering Department, the use of prestressed concrete with tendons for foundations may require 68.5 percent less steel than is used with ordinary reinforced concrete. The use of prestressed concrete with tendons for foundation beams may result in a saving of 40.1 percent of the steel used with ordinary reinforced concrete. Since both high-tension and cold-drawn steel wires can be used as tendons, prestressed concrete is suitable for the present economical and technical conditions in China. Moreover, because of the high quality and light weight of prestressed concrete structures, the whole country should learn how to apply tendons before using prestressed concrete with large cables. According to workshop experience of the Taiyuan Steel Company, starting with post-stressing large-sized steel cables may also yield good results. For production purposes, only two hydraulic jakcs, four vibrators and one drafting machine are needed. All the facilities cost less than 50,000 yuan. Within one year, the company produced 2,000 cubic meters of prestressed concrete. The quality was good and the production cost was relatively low. Now, therefore, construction units with less experience and less favorable conditions must begin on the basis of general existing conditions; they should try to take advantage of the local environment, starting with simple designs or with post-stressing techniques and then extending the scope of application. This measure will guarantee the success of the great leap forward in using prestressed concrete. Besides promoting the use of various prestressed concrete structures such as roof beams, roof trusses, supporting trusses, cantilever beams and slabs, construction units with sufficient experience should try to use particular prestressed concrete structural members such as long-span trusses, composite columns, tall trusses, precast thin shells, precast cooling towers, precast oil tanks and water conduits on a large scale. Finally, we have to go still further, continuously improving our prestressed concrete production and construction techniques and setting ourselves a still higher standard.

For gaining better results in promoting the use of prestressed concrete, we must affirm the priority of political guidance, by complying with instructions of the Communist Party and earnestly conforming to the following suggestions:

1. Concerning general policy, practical measures and promotion plans must be determined. For 1960 the materials for prestressed concrete tendons should be deformed reinforcing material and low-carbon, cold-drawn wire. The high-tension construction units should consider using trusses and cantilever beams with strands and steel wires first. Priority

should be given to standard structural members and type designs, and special preference must be given to new designs of structures which are economical and of good quality, such as composite trusses of the linear, prestressed type.

2. Concerning facilities, plans must be made to utilize fully the potentialities of existing facilities. If possible, the policy of centralized coordination, mutual assistance and maintenance, and self-manufacturing facilities should be adopted. Special-purpose workshops must be established to produce standard structural members from high-strength, fast-coagulating cement, so that the rotating system of using the facilities can function fully.

3. Concerning maintenance, the quality and quantity of prestressed concrete structures must be guaranteed from the time of production to installation. This can only be achieved by the system of self-inspection, mutual inspection, and technical inspection. Construction groups should be organized to facilitate the inspection system and the technical training. The preparation of high-strength cement for new, experimental designs and for large-scale production of structures must be skillfully handled. Special attention must be given to tension control, to accuracy of dimensions and solidity of slabs and structural members, to the handling of anchor units and to the quality of cement grout for filling holes by injection.

4. The technical potentialities of all personnel working with prestressed concrete should be made fully functional; workers should be encouraged continuously to make all kinds of technical improvements, to learn from the experiences of other countries, and to combine design, construction and research efforts into a functional whole. Workers should undertake to promote the use of prestressed concrete, on the one hand, and to raise the general standard, on the other. The technical staffs should help solve the difficulties of the construction units, study and improve the techniques of construction work, and extend the scope of application so that the international standard for the use of prestressed concrete can be attained within a very short time.

5. For effectively promoting the broader use of prestressed concrete on the basis of present conditions, it is most necessary either to establish special prestressed concrete working units or to organize special technical units which would include the main structural member production groups in the relatively large construction industries, production plants and prestressed concrete construction sites. This is an advantageous measure which may guarantee the engineering quality, raise the technical standard, and help promote the use of prestressed concrete.

All workers and staffs of construction must understand clearly that the promotion of the use of prestressed concrete may save great amounts of steel and other materials, and money. Furthermore, its use can fully utilize existing materials so that more and better factories and civilian houses may be built, which will strengthen both the construction industry and the national economy.

On every working front throughout the nation, we have been fighting for a general victory in 1960. We are confident that, all conditions being favorable, the promotion of the use of prestressed concrete will be successful.

PRODUCTION OF ASSEMBLED TRUSSES WITH PRESTRESSED MEMBERS MADE OF 1,000 CONCRETE

/Following is the translation of an excerpt from an article of the above title written by The Peiping Second Construction Company, appearing in Gongchung Jianshe (Engineering Construction), pp. 4-5./

In 1958, assisted by the Institute of Construction Engineering Research, Department of Metallurgy, Construction Metallurgy Institute, and by the Research Institute of the Bureau of Construction, Peiping, our company succeeded in making assembled trusses with prestressed members of 1,000 concrete in the laboratory. In July 1959, formal production began.

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II. Choice of raw materials and processing

Cement: The new 800 cement produced by the Chiangnan Cement Plant was used. Its characteristics are: fine grain, and hence density up to standard /thus requiring more water than normally/, strong adhesion between cement and concrete, high heat hydrolysis, high strength in early stage, sensitivity to surrounding temperature and to quantity of water used, and great sensitivity of density to the quantity of water. Steam treatment of this product not only fails to increase its grade but induces brittleness.

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Steel wire: The designed strength is 13,000 kg/sq cm; however, there must be grooves around the wire, and cutting these reduces the strength by eight percent. Therefore, initially the wire must have a strength of 14,000 kg/sq cm. But considering that the supply of steel wire is insufficient and that the reduction of strength by the grooving treatment is not too serious, all wires with strength of 13,000 kg/sq cm or above is considered usable. ø 4 steel wire may have strengths up to 16,000 kg/sq cm, which is more than sufficient. The groove treatment, shown in Fig. 8, must produce grooves of the proper size, for the strength may be seriously reduced if the grooves are too deep, whereas the binding will be insufficient if the grooves are too shallow.

CONSTRUCTION OF PRESTRESSED CONCRETE CIRCULAR TANK BY THE ELECTRICAL PRESTRESSING METHOD

/Following is the translation of an excerpt from an article of the above title written by The Second Engineering Bureau, Construction Engineering Department, appearing in Gongchung Jianshe (Engineering Construction), page 13./

The storage tank of the Fu-huo-hao-teh Sugar Refinery built by our Bureau under contract is constructed of prestressed concrete. Its volume is 3,200 cubic meters, its diameter, 23 meters, and its height, 8.45 meters. Calculations show that it may store liquid up to /a column height of/ 7.75 meters. In comparison with steel tanks of similar size, the use of prestressed concrete saves 35.7 tons of steel and reduces the construction cost by 81,000 yuan.

OPINIONS GATHERED FROM THE TECHNICAL SYMPOSIUM ON PRESTRESSED CONCRETE PRESSURE PIPES AND OIL TANKS

/Following is the translation of an excerpt from an article of the above title written by Jen-wen Hwa, Hsiu Pei and Yi Sung, appearing in Gongchung Jianshe (Engineering Construction), pp. 19-26./

In our country, prestressed concrete pressure pipes have been gradually adopted for industrial and civil constructions. At present circular prestressing methods are confined to (1) the /Po Si Mor/ stress control method, (2) the load stress control method and (3) the friction-wheel stress control method. But all three methods lack control stability and hence breakage always results, which wastes materials, and the quality of pressure pipes is affected, which leads to low net production. In manufacturing large-diameter pressure pipes, the old methods of prestressed wiring do not apply. Therefore, it is necessary to improve the techniques for producing prestressed concrete pressure pipes to meet the requirement of general production.

The Reinforced Concrete Research Center of the Construction Research Institute, Construction Engineering Department, suggested that part of the stressing be accomplished electrically during the winding process so that the mechanical stressing required could be greatly reduced, thus remedying the weakness of the old methods and reducing the weight of facilities.

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During our research we have actually used this technique in making prestressed concrete pressure pipes 1.75 meters in diameter. The above diagrams in this article show the winding process. A pressure of ten atmospheres was applied for eight hours to test the pipe, and its quality was proved good.

During the winding experiments, no breakage of steel wires occurred, and therefore this treatment will be satisfactory for production. If the electrical treatment facilities are sufficient, production efficiency can be increased. Both experiments and theory show that the stress control is stable. Since the mechanical stressing has been reduced, the size of the winding facilities has also been reduced and

other mechanical arrangements have been simplified. The newly designed continuous electrical winding machines for factories incorporate the above-mentioned merits. Structural members of other geometric forms can also be produced by modifications of the above facilities, hence extending their usefulness.

Since the variety of high-tension steel wires produced in our country is still limited, we have studied the potentialities of only two kinds of steel wires. To utilize materials currently available, we also carried out experiments on the potentialities of cold-drawn steel wire. The results show that it is proper to use this kind of steel wire for continuous electric windings. In the future when more types of steel wire are available, electrical treatment experiments will be carried out to obtain the required data.

Continuous electrical winding is a new technique. It points to a new direction for the mechanized production of prestressed concrete structural members. Its future will be certainly bright.

STANDARD OF VARIOUS GRADES OF WORK WITH PRESTRESSED CONCRETE

Grade	Basic techniques and knowledge	Jobs and skills
Third grade	1. Characteristics of prestressing and post-stressing methods.	1. Skillfull handling and maintenance of the /Dien-don-hulu, an electrical device to cause tension./
	2. Connection of prestressing systems and principles of the transfer of prestress.	2. Handling of the tensioning and anchoring of steel wires.
	3. The maintenance of prestressing tools, anchorage plates and stranded rods.	3. Preparation of mortar grout for holes and gaps according to formula.
	4. The use of meters and scales.	4. Use of prestressing tools.
	5. Types, specifications and dimension of regular steel wires.	5. Connections between jacks /Yiu Sheh/ and prestressing frame.
	6. Calculation of area, circumference and percentage.	6. Help to prepare concrete under the direction of foreman.
	7. Items to be inspected and the order of laying steel wires.	7. Under the direction of foreman, assist him in assembling steel wire frame according to a specified plan.
		8. Use of big hammers, small hammers and saws for straightening and flattening.

Fourth Grade	1. Basic principles of prestressing.	1. The operation and maintenance of drafting machines.
	2. Properties and capacities of single-purpose jacks.	2. To direct prestressing and anchorage of complicated steel cables.
	3. Principles and properties of joining prestressing systems such as stranded rods.	3. To direct cold-drawn steel wire processing and to control time effects.
	4. Prestressing conditions, order and methods.	4. To read simple blueprints such as steel bar connections and arrangement of steel cables.
	5. Security measures for cold-drawing and prestressing.	5. To handle grouting methods.
	6. The relationship between the particular work involved and other grades of work.	6. To direct correctly the inspection of slab holes and the binding of steel wires.
	7. Proportions for mixing concrete, and properties of concrete.	7. To use the single-purpose jack and to handle simple linear prestressed concrete structural members and their anchorage.
	8. Ordinary insulators and application of insulation tools.	8. Application of strands, bars and steel wires.
		9. To use wire connectors, pulleys, capstans and prestressing machine.

Fifth grade	1. Dual-purpose jacks, their basic structure and characteristics.	1. To use strain gage and percentage tables.
	2. The characteristics and basic structure of drafting machine.	2. To direct production of large- and small-sized strands.
	3. Various kinds of anchors (wedge plates and bearing plates) and their capacities; principles of anchorage.	3. To read general diagrams and to recognize spare parts.
	4. Items to be inspected and procedures for applying grout on holes and gaps.	4. To estimate the quantity of materials used.
	5. The significance of the water-cement ratio /to the/ density of the concrete.	5. Arrangement of construction site and organization of labor.
	6. Requirements and orders of assembling blocks and items to be inspected.	6. To undertake security measures in applying cement mortar.
	7. Specification of the maximum load of steel wires.	7. To use dual-purpose jacks for prestressing and handle anchorage.
	8. Tensioning method and required qualities of mortar grouting.	8. To use ordinary drilling machine and grinding machine to turn out general spare parts.
		9. To use files for repair and general filling.
		10. To read interchangeably stress and pressure gages.

Sixth grade	1. Characteristics and structure of cement mortar.	1. To direct security arrangements for electrical prestressing operations.
	2. Structure and capacity of electric and hand push /Yiu Sheh/.	2. To read voltmeter, ammeter and /Yao Piao/.
	3. The principle governing cold-drawing and the effects of time on the process.	3. To be skillful in using and maintaining prestressing machines and facilities.
	4. Inspection of the quality of mortar grouting.	4. To make simple general tools and anchors.
	5. Preparation of mortar grout.	5. To make friction piles according to given load specifications.
	6. Functions of structures, conditions of ordinary steel wires and quality requirements.	6. To design spare parts such as anchor plates, clamps and connectors.
	7. Distinction between AC and DC, and the relationship between current, resistance and voltage.	7. To estimate the total cost of materials.
	8. Calculation of the length of tendons before and after cold-drawing.	
	9. Various factors affecting the control of prestressing.	

Seventh grade	1. The principle governing the loss of prestressing strength, and methods to reduce such loss.	1. To direct manufacture of complicated curved structures and to handle prestressing and anchoring of special structures.
	2. Specifications of various kinds of anchors and connectors, and requirements of materials.	2. To use the level and the theodolite.
	3. Analysis of the cause of the bending of tendons and methods to alleviate it.	3. To calculate current, resistance and voltage, and the conversion of electrical into heat energy.
	4. Analysis of the causes of sliding, breakage, noise, sudden change in the oil gage, and uneven stretch; general treatments.	4. To calculate the stretch.
	5. Characteristics of the mechanics of steel, and the relationship between stress and deformation.	5. To carry out experiments on structures with load capacities under 10 tons according to known data.
	6. Calculation of the cross section of the steel wires on the basis of given strength and controlled stress.	

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